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THE GRAFTING OF AMERICAN GRAPES

F. E. GLADWIN

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F. E. GLADWIN

SUMMARY

Grape grafting may be employed to change an established misfit variety to one that is more desirable. It may also be used to propagate vines. Grafting of the grape on resistant stocks may eliminate the phylloxera as a vineyard pest.

Cleft-grafting of the vine is largely used to work over undesirable varieties, while bench-grafting is employed for propagation and to secure phylloxera-resistant roots.

The different species that are used as stocks, as well as the varieties that are ordinarily used as scions, differ widely in their affinities, so actual tests are necessary to determine the relationships.

The time that cleft-grafting is to be done is a most important consideration. Two periods favor success, one some time previous to the beginning of active sap flow, the other after the vigorous flow is past.

The exclusion of air thru the use of grafting wax or other materials results in but few takes.

The cambium layer of stock and scion must be brought in close contact at one point. The larger the area over which they coincide the better.

Excessive moisture about the joined parts retards the development of healing tissue.

The drying out of the tissues over the cut surfaces of stock and scion may be prevented by a mound of loose soil carried to just below the top bud of the scion. If the soil does not bake, even the top bud may be lightly covered. In wet seasons this mound should be leveled occasionally and the soil about the union allowed to dry.

Suckers and scion roots should be removed at intervals the first season.

Bench-grafting may be successfully done thru hand cutting or by the use of a grafting machine.

In this work the English whip-and-tongue method has been used exclusively.

Bench-grafting of the grape is not advisable longer than six weeks previous to the time that the grafts are to be planted out in the nursery.

Either one-year-rooted plants or cuttings from the canes of the previous season may be used for stocks. The latter are more easily handled in grafting, callusing, and planting out. The successes are just as great with the one as with the other. If cuttings be used for stocks, they should be cleanly dis-budded.

In bench-grafting the stock and scion must be of like diameters, whether the one-year root or cutting be used as stock.

Shorter bevels appear to give more complete healing than longer cuts.

The cambium layer of both stock and scion should be in close contact over the greater portions of the cut surfaces.

A minimum of waxed string should be used to hold the joined parts in close contact until callusing has taken place unless the stocks are large, and great care should be used in packing and in removing from the boxes.

Tests indicate that bench-grafted roots or cuttings may be well callused before planting if the grafts have been packed upright in wooden boxes so that a layer of water-saturated sawdust is interposed between the sides of the box and the air of the room. The sawdust holds the heat within the box and at the same time provides a humid chamber.

Excessive moisture retards callus formation while heat favors it.

Experiments made in 1922 showed that a mean temperature within the boxes of 76° F. over a period of 27 days was sufficient for good callus formation. In 1923 excellent callus pads were developed after 21 days at a mean interior box temperature of 70° F. The mean room temperature for the same period was 78.2° F. Tests in 1924 showed that 22 days with a daily mean of 74.6° F. were necessary to grow good callus pads. The daily mean for the room over the same period was 81.4° F. Several factors intervene to make the heat requirement variable.

The quantity of heat necessary to develop a sufficient amount of callus probably varies with species and varieties and from season to season.

Cuttings or root grafts should not be exposed to the sun or to warm, drying winds.

They should be planted in the trench or furrow so that the union will be an inch below the soil surface when the trench is filled.

The soil should be well tamped about the grafts, especially at the butts.

After the furrow has been filled, a ridge should be brought up so that the soil is just below the top bud of the scion.

All suckers from the stocks should be removed as fast as they appear.

Two or three times during the growing season the soil should be cleared away down to the union and all scion roots cleanly cut away. The soil should then be brought back to the original level.

Well-made and callused grafts of Concord, Catawba, etc., will probably give a 50 per cent stand of satisfactory plants in the average season.

INTRODUCTION

The grafting of grapes may be practiced for one of several reasons. In its beginning grape grafting was done almost entirely for the purpose of changing an undesirable variety growing in a favored location or occupying valued space to a better sort with a minimum loss of fruit. It has happened not infrequently that grape vines bought and planted under the name of one variety have turned out anything but the ones ordered. There are apt to be less misfits in the large order of the commercial grower, for the filling of small orders with many varieties affords greater opportunity for error. The admixture of odd varieties of but few vines in the commercial planting contributes in no small degree to the overhead of the vineyardist, for the misfits often entail harvesting at various periods and, when scattered thru the planting, may make necessary walking over a large area for a very little fruit. Oftentimes the fruit from the odd varieties is unsalable by reason of its poor quality, or there may be so little of it that it cannot go into solid car shipments. The misfit,

however, occupies just as much soil space as does the principal variety.

With the home gardener who usually has a very limited area that can be given to fruit, it is a sore disappointment to find that two of the five varieties which he has nursed along to the fruiting stage are but inferior misfits.

Vineyard grafting of untrue varieties can remedy the trouble both for the commercial grower and the amateur.

In more recent years grape grafting has assumed another aspect in that it has become a means for the propagation of vines. The reconstitution of the vineyards of France, as is well known, has come about thru the grafting of the cultivated sorts on American roots that are resistant to phylloxera, which all but wiped out French viticulture. In California it was found to be necessary to graft the Vinifera varieties grown in that state on resistant, wild American species and varieties to get away from the same pest.

Still more recently, it has been found that, aside from the resistance afforded to the root louse thru the American wild species, quality, vigor, and productiveness of some American varieties have been greatly increased thru grafting on the so-called resistants. Bulletin No. 508 of this Station discusses in detail data obtained from experiments concerned with the use of certain wild and one cultivated variety used as root-stocks for several native varieties of grapes.

Hence, grape grafting may be advisable for one or more of the purposes herein stated.

PURPOSES OF THE TESTS

The methods and facts discussed in this bulletin concern themselves with two types of grape grafting which it is believed will be of interest to the majority of grape growers. Consideration is given first to the working over of varieties already established in the garden or vineyard to more desirable sorts thru cleft-grafting, and next the propagation of desired varieties thru bench-grafting of vine cuttings or of one-year roots before they are planted in their permanent locations in the vineyard.

CLEFT-GRAFTING

Many failures have been reported from time to time with cleft-grafting, hence the chief purpose of the present work with this

method has been to learn some of the contributing causes for the failures and to test out details of the operation that might overcome the troubles encountered. The discussion of vineyard cleft-grafting that follows is based on observations made over a period of years in the Station vineyards at Fredonia.

BENCH-GRAFTING

While bench-grafting is a very old practice, little experimentation has been done with American varieties as scions. The recommendations available for bench-grafting and for handling the grafted cuttings and roots of Vinifera until they are ready for vineyard planting are applicable only in part, and should some of the details be carried out in the East failure would result.

In the preparation of the necessary plants for the experiments discussed in Bulletin No. 508 many difficulties were encountered, even tho the accepted practices of California and France were followed. Hence, it was found necessary to fit the best of each to conditions as they prevail in the East. Changed climatic conditions and the use of American varieties presented quite different problems. It has been the purpose of these studies, then, to test desirable methods of grafting and to study the care of the grafted cuttings and plants until such time as they should go in the nursery and also their care in the nursery.

VINEYARD GRAFTING

Our observations on vineyard grafting have been solely with the ordinary cleft-graft that is commonly used in orchard work. We have used this method exclusively in working over the stocks that failed in our vigorous stock experiments. It is quite probable that all varieties do not take equally well on a given stock and that many failures in cleft-grafting may be traced directly to a lack of affinity between stock and scion that is known to exist from our studies discussed in Bulletin No. 508. For most of the varieties used in those tests, it was shown that Clinton and its closely related derivatives were generally desirable as stocks. It is probable that Clinton or varieties of its type are the ones most frequently found mixed in plantings of Concord, Worden, and Moore. We have shown previously that the affinity of Campbell, Delaware, Niagara, and Catawba is close, so

that if the operation be carefully performed success should result from using these varieties on Clinton.

TIME FOR CLEFT-GRAFTING

In our vineyard grafting we have learned that there are two periods in the spring when the operation can be done with equal success. The first period is rather early in the spring before there is any upward movement of the sap, while the second period occurs after the vigorous sap flow has passed. All things considered, the first period should be given preference as the scions at that time are in complete dormancy. If it is found impossible to graft at either of these periods, then the stocks to be grafted should be cut off a trifle higher than where the grafting is to be done several days before the actual work is to be performed.

THE STOCKS

It has been our plan to graft 2 or 3 inches below the soil level, altho this is dependent on the straightness of the trunk at that level. It may be done slightly lower and sometimes an inch higher. The closer to the normal soil level it is done the less the liklihood there will be that scion roots will strike. Also, if the graft level is a few inches below the soil, the chances for renewal trunks close to the ground are much greater. The stock is cut cleanly across with a small hack saw at least 2 inches above a straight piece of trunk and, as before stated, 2 or 3 inches below the soil level. It is not advisable to attempt cleft-grafting of the grape with stock less than a half inch in diameter. With the hack saw a slot is sawn on the face of the cut stub to a depth of 1½ inches at right angle to the length. The slot is now opened with a narrow wooden wedge for the insertion of the scions. The upper figure Plate I shows the stub sawn across and ready for the sawing of the slot. The top of the sawn surface is below the soil level, but for photographic purposes it is made to appear as if above the soil level.

THE SCIONS

The scions of the varieties that are desired for grafting should be taken from the parent vines sometime during the dormant period and stored in a cool place, but they must not be allowed to dry.

They keep to the best advantage in outside, well-drained soil. Before the period of grafting comes, however, they should be placed in a cool room, as the outside temperatures in early spring are often sufficient to awaken growth. The scions may vary in length from two to four buds, depending on the variety. Some varieties, independent of the season, are much shorter jointed than others. Such varieties will consequently carry a larger number of buds in a given length.

The lower end of the scion is cut to a wedge with a bevel varying from 1½ to 2 inches in the same manner as the scion is cut for apple grafting. The wedge should begin as close to the basal bud as possible, while the outer edge is cut thicker than the inner. It is now inserted in the slot that has been opened with the wooden wedge with the bud to the outside and close to the sawn surface. It is forced as deeply into the cleft as can be done without breaking. In order that the cambium tissues of the stock and scion may come in contact somewhere along their cut surfaces, the top of the scion is tilted a little outward. This insures that at least one point of the cambium of each meets. If the stock be of sufficient diameter, two scions are inserted, one to either side. The wedge should then be removed without disturbing the scions. By taking hold of the tops of the scions and moving the hand slightly, it can be determined if the scions are held securely. If they are loose, they must be forced deeper into the cleft. Plate I, upper figure, illustrates a vine stub sawn below the soil level, while the lower picture shows the cleft sawn and opened with the wooden wedge, together with the tools used. Plate II, left, shows the inserted scion, while the photograph to the right illustrates the sole tying that is necessary—two or three turns of strong soft twine. In soils of very fine texture it may be desirable to exclude the particles from the cleft. This can be done readily by the use of an ordinary piece of wrapping paper as shown in Plate III, upper figure. The lower photograph in Plate III illustrates the same scion covered to the upper bud with a mound of loose soil. The bud just can be seen to the right and at the top of the mound. All waxes and coverings that exclude air from the joined parts must be avoided as good aeration is requisite for the formation of knitting tissue. Heavy soils used for forming the mound may cause failure either from extreme compactness and hence exclusion of air, or thru excessive drying by reason of large lumps of soil. If the season be one of

much rainfall, it will probably be necessary to remove the mound once or twice during the growing season and allow the soil to dry about the joined parts, after which the mound is again raised. If the grafting has been done during the active flow of sap, the above procedure is all the more necessary in order that the sap poured into the soil may be removed thru evaporation. It is probable that most failures in vineyard grafting have come from the exclusion of air and an excess of moisture about the joined parts.

As fast as suckers from the stock appear above ground they must be broken off, care being taken that the scion is not disturbed. It is also advisable to place a stake close to each grafted stock, and when the shoot from the scion has grown to a sufficient length it should be tied to the stake. The growth of a shoot on a scion on a well-established stock is usually of such length that it may be trained on the trellis the following season.

For two or three seasons after grafting it is advisable to hoe away the soil from about the union and cut off any roots that may have grown from the base of the scions. These should be cut away cleanly and close to the old wood. Likewise, any suckers that arise from the stock should be broken off from time to time.

With stocks and varieties of average vigor there should be sufficient cane growth at the end of the second season to insure a full crop. If the stock and scion lack congeniality, it may require several seasons.

BENCH-GRAFTING

It has already been noted in Bulletin No. 508 that the experiments reported on were more or less impeded thru failure to secure a good lot of plants thru bench-grafting. While poor stocks and scions will account for many of the failures, it was felt that the technic employed, especially in the handling after the grafting was done, was faulty. This belief has been justified as a result of our tests during the past several seasons. We have used the English whip-and-tongue method as we believe it will meet most requirements and it is readily learned.

HAND AND MACHINE GRAFTING

The earlier work was done thru hand-grafting, that is the stock and scion were fitted by the worker with the ordinary grafting knife.

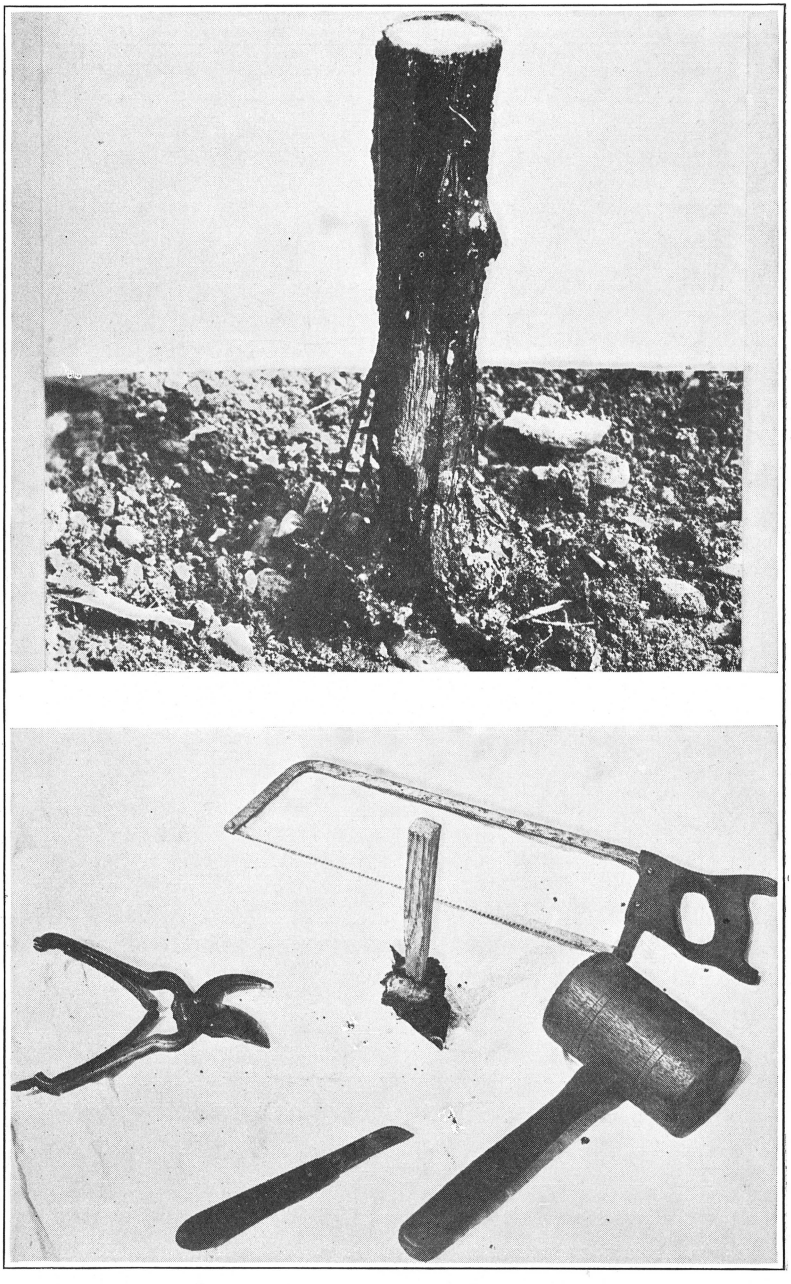


PLATE I.—STUB WITH SAWN SLOT OPENED WITH WEDGE, AND TOOLS USED IN VINEYARD CLEFT-GRAFTING.
Above, GRAPE TRUNK SAWN JUST BELOW THE SOIL LEVEL PREPARATORY TO GRAFTING.

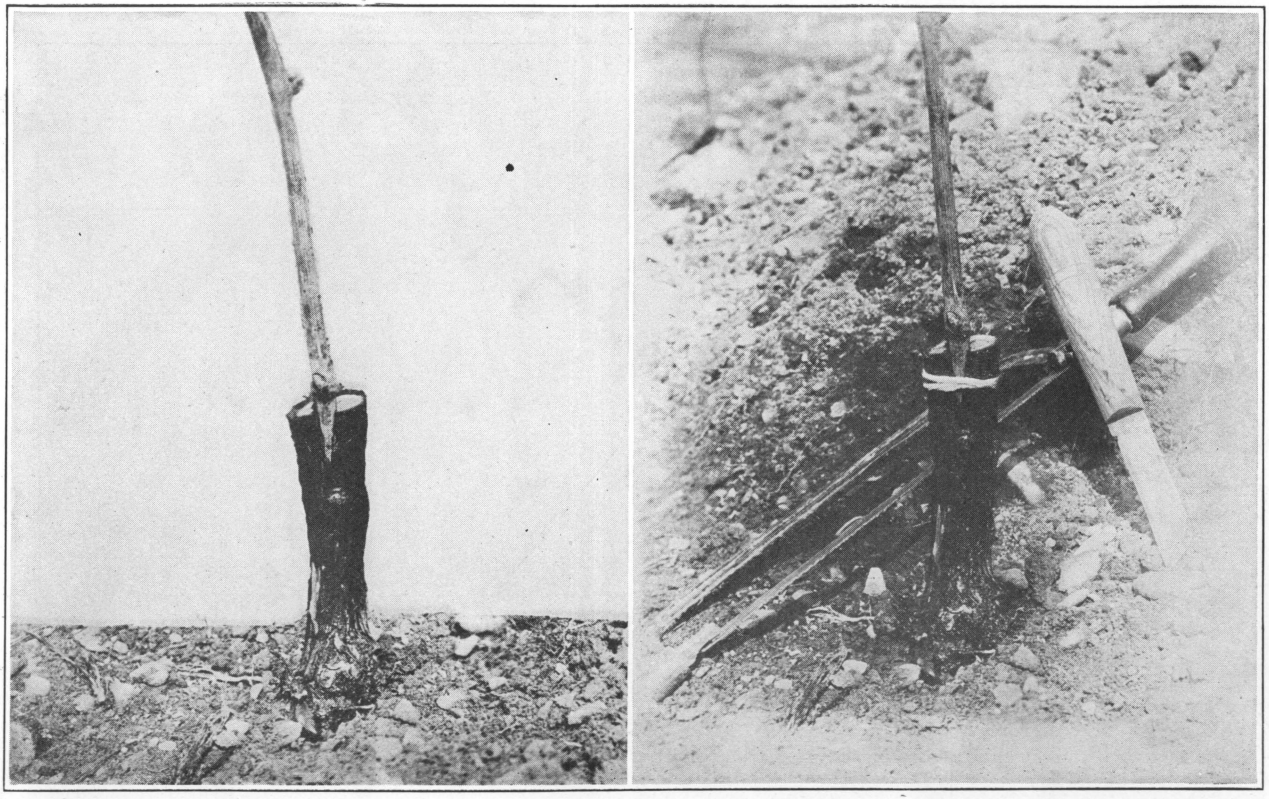


PLATE II.—*Left*, STUB WITH SCION INSERTED READY FOR TYING.—NOTE BASAL BUD OF SCION CLOSE TO JUNCTION OF PARTS. *Right*, INSERTED SCION TIED AND READY FOR MOUNDING.

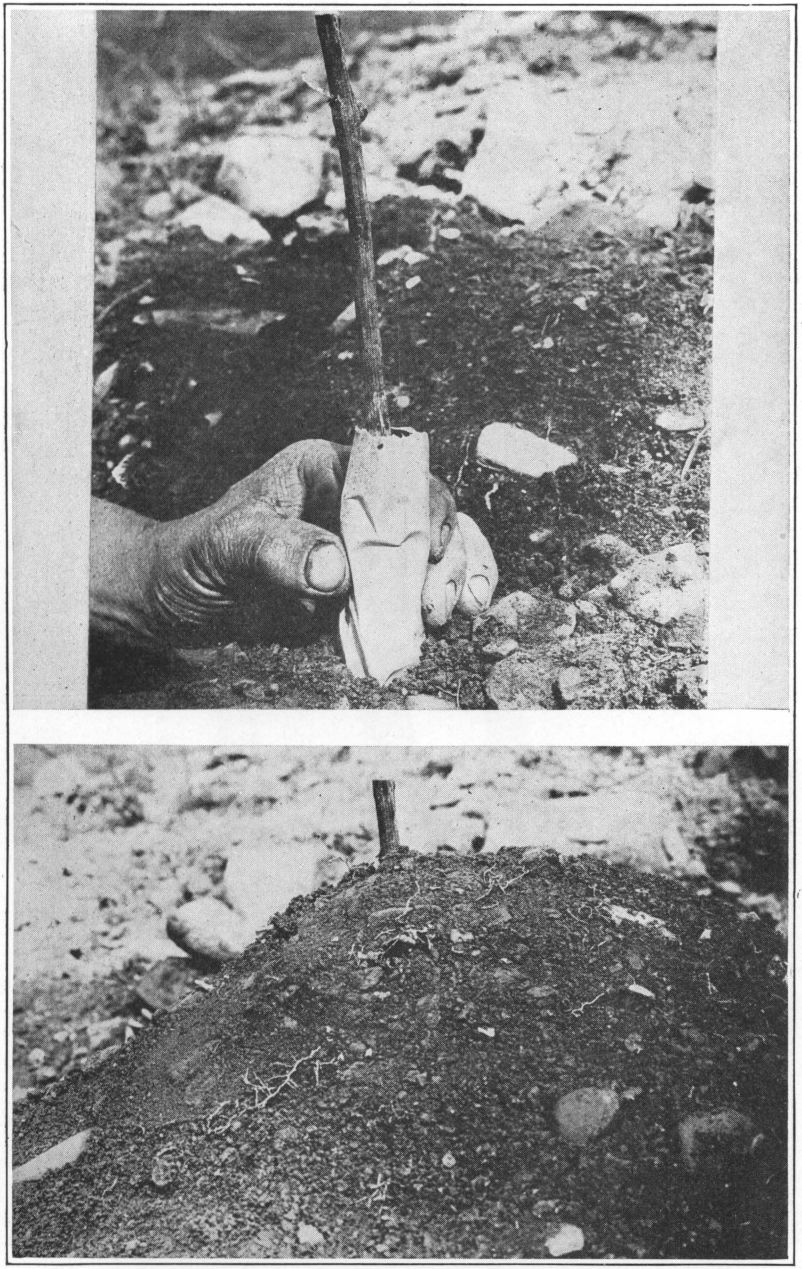


PLATE III.—SOIL MOUND RAISED TO JUST BELOW TOP BUD OF THE SCION. *Above*, EXPOSED PARTS OF THE GRAFT COVERED WITH WRAPPING PAPER.

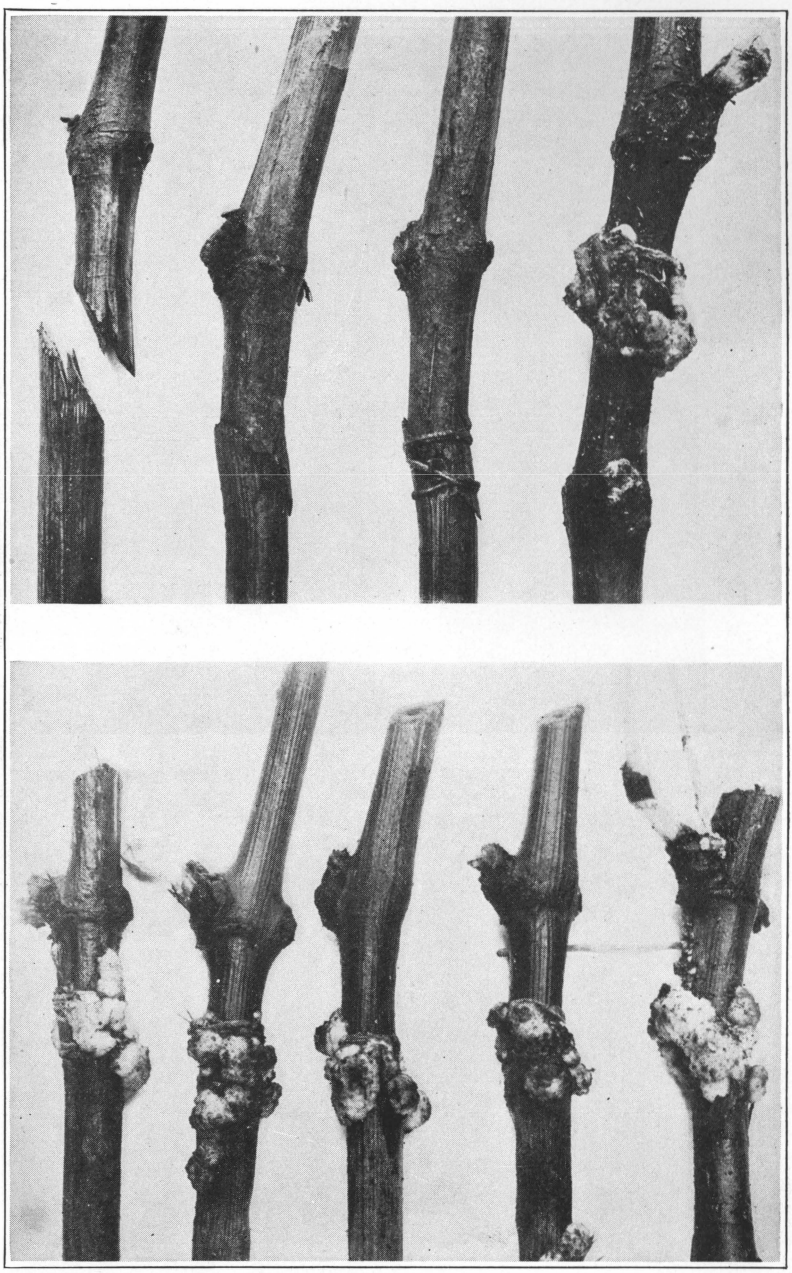
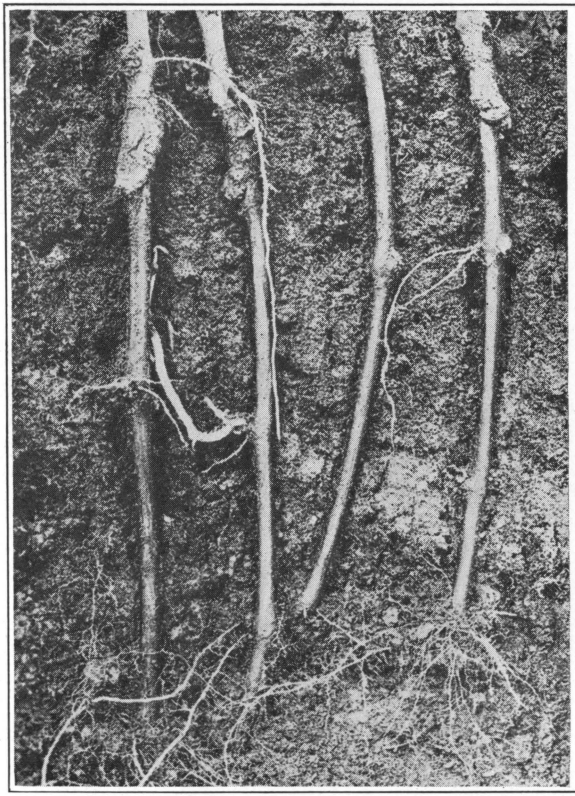


PLATE IV.—GRAFTED GRAPE CUTTINGS UPON REMOVAL FROM CALLUSING BOX, NOW READY FOR NURSERY PLANTING.
Above, STOCKS AND SCIONS CUT FOR WHIP-AND-TONGUE GRAFTING, JOINED, TIED, AND CALLUSED.



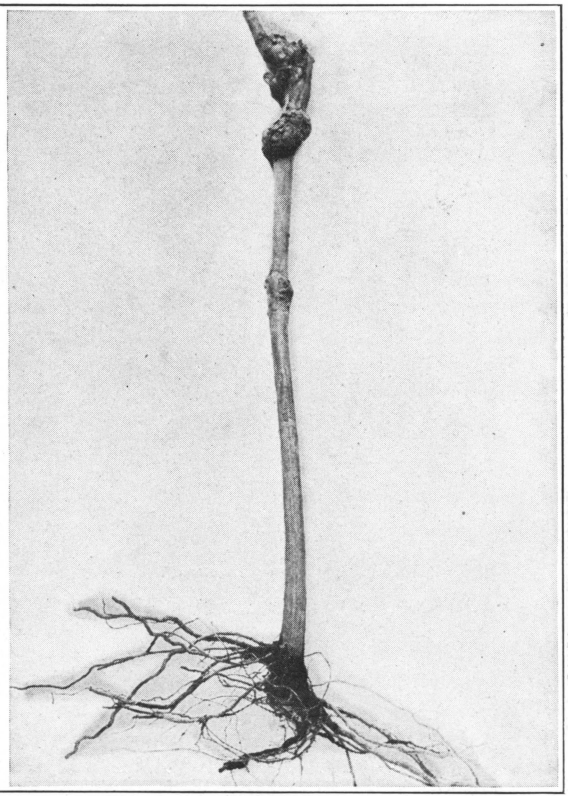


PLATE V.—*Left*, GRAFTED GRAPE CUTTINGS TAKEN FROM CALLUSING BOX AND NOW GROWING IN OBSERVATION FRAME. NOTE THE FORMATION OF A SCION ROOT IN THE GRAFT TO THE LEFT AND A SUCKER GROWING FROM THE STOCK OF THE SECOND GRAFT.

Right, A GRAFTED GRAPE CUTTING AFTER GROWING IN THE NURSERY FOR A YEAR. NOTE THE ENLARGEMENT AT THE POINT OF UNION.

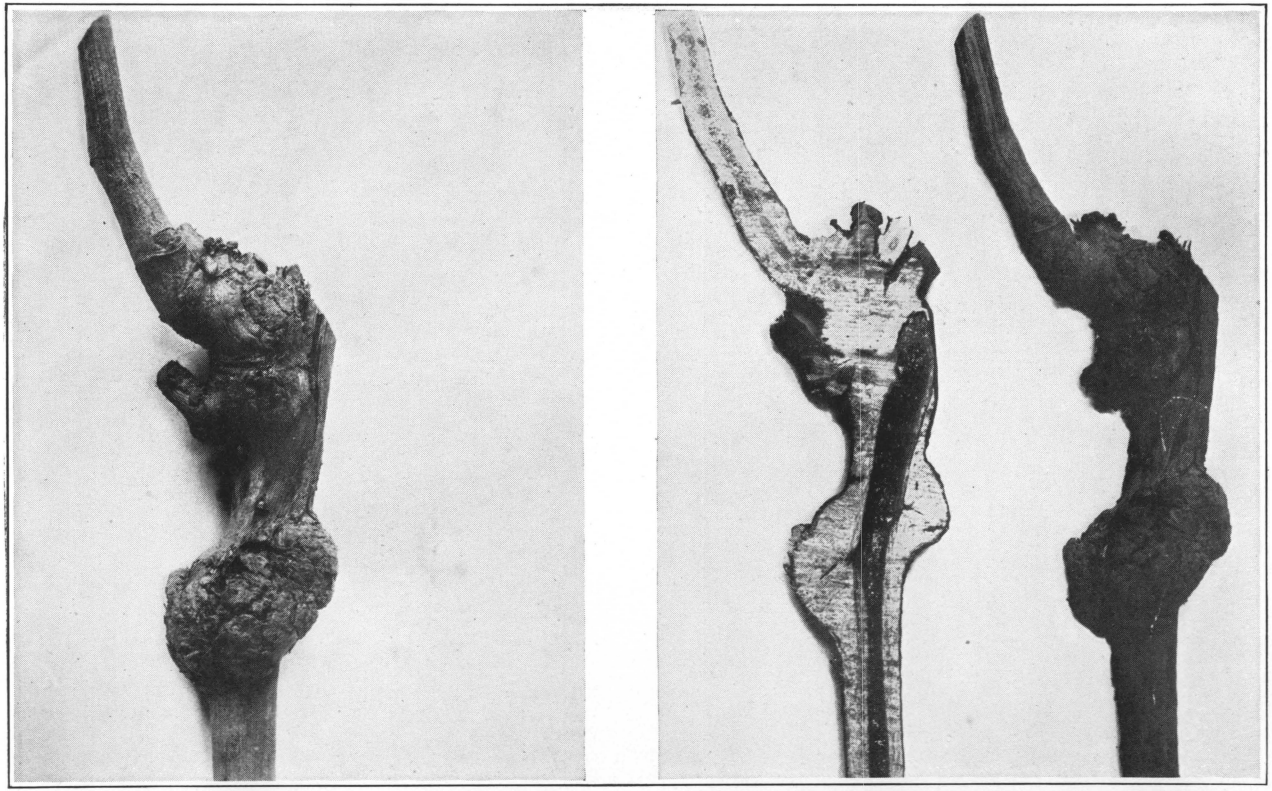


PLATE VI.—*Left,* A CLOSE-UP OF THE UNION SHOWN IN PLATE V.

Right, THE SAME GRAFT SAWN LONGITUDINALLY THRU THE UNION. NOTE THE CONTINUITY OF THE TISSUES OF STOCK AND SCION.

Two cuts for both stock and scion are required. These are exactly alike for both. Beginning with the scion, which is of one-bud length, at a point near a bud, a bevel is cut from one side of the cane to the opposite side. This cut surface, which varies from five-eights of an inch to an inch, exposes the various tissues that make up the cane. In order that smooth bevels be cut, it is necessary that the cutting be completed with one stroke of the knife. Subsequent paring results in uneven surfaces that do not make intimate contact with the parts that are to be fitted. The stock, which may be a piece of cane cutting or a one-year root, is beveled in like manner about 9 inches from the base. At a point one-third from the top of the bevel of the stock, a slot is cut down the cane or stem to a distance of one-half the remaining length of the bevel. With a beveled surface of five-eights of an inch on the scion, this slot should be cut to a depth of approximately one-fifth of an inch. The slot almost parallels the long dimension of the stock. A slot is similarly cut from a point on the bevel face of the scion. Plate IV, upper figure, shows a stock and scion cut after these suggestions. These pieces were cut by machine, however. Those cut by hand usually have longer bevels, but the relative location of the slots are the same, whether they are machine or hand cut. As has been previously stated, the stock and scion must be of like diameters. It is not pertinent at this time to go into a discussion of the merits of the long and short bevel, but it is believed that the smaller the amount of pith exposed the greater will be the number of takes. The upper photograph in Plate IV shows the scion and stock joined, tied, and ready for callusing. The tongue of one fits into the slot of the other and vice versa.

For the past several years we have used a French grafting machine made to cut the bevel and slot of both stock and scion at one operation. There are several such machines on the market, but as we have used but the one we cannot discuss their merits. The grafting machine possesses two marked advantages over hand grafting, namely, that in the hands of the inexperienced it is much faster and that no matter how unskillful the operator may be the cuts are truer when made in this way than when made by hand. The greatest objection to the use of the French machine is the inability to get knives and parts quickly should they be required.

THE SEASON FOR BENCH-GRAFTING

In the latitude of western New York bench-grafting should not be started much before late March. In milder climates it should be begun much earlier. The grafts may be held several weeks without deterioration, if they are not subjected to freezing temperatures or heat, or to excessive moisture and dryness. The stocks and scions should be taken much earlier than this and kept in complete dormancy.

ROOT AND CUTTING GRAFTING

Either one-year roots or cuttings of one-year wood may be used as stocks for bench-grafting the grape. It would seem that the rooted stock would be more sure to make a union and, in consequence, a better plant than the joining of a scion on a cutting without roots. Our observations indicate, however, that such is not the case, but rather that cuttings as stocks give a greater number of takes and just as many well-rooted vines. As will be shown later, grafted cuttings are more convenient to handle than grafted roots.

The one-year-rooted plant that is to be used as a stock should have its roots cut back to within 2 or 3 inches of the base, while the top is pruned so that but a piece of the trunk 8 or 9 inches in length remains. Cuttings when used as stocks should closely resemble ordinary grape cuttings and should be of a length similar to the one-year root, with the exception that the part above the upper bud is slightly longer. In either case the cuts are made as closely to the nodes as possible. With both, the scions carry but one bud, and here, too, the bevel is made close to the bud. The manner of tying is shown in the upper figure in Plate IV. For this purpose Dexter Cotton string No. 16 that has been impregnated with grafting wax thru immersion a few minutes in the liquid wax has been found satisfactory. But a few turns of the string are necessary. Our tests in 1924 indicate that tying may be unnecessary with large stocks and scions when callused in boxes.

CALLUSING

The usual recommendations imply that bench-grafted roots or cuttings may be satisfactorily callused in sand, either in the open ground or in a cold frame. Our tests show that neither of these practices is of value in the East. The spring temperatures are not

sufficiently high, while the rainfall is likely to be excessive for the formation of healing tissue. The study of many thousand bench-grafted roots and cuttings in relation to the formation of callus pads indicates that knitting tissue will not form without high and constant heat and a minimum of moisture. Thus far, we have been entirely unsuccessful in getting cicatricial tissue to form freely either in the open ground or in the cold frame filled with sand. While callus formation before nursery planting may not be requisite to a proper union, nevertheless we are of the opinion that the free formation of knitting tissue before planting is a good index of ultimate success. The liklihood of uncallused grafts being disjointed in their transfer from storage to the nursery is much greater than in well-callused ones. Our tests show further that those grafts which form no callus under optimum conditions do not do well later in the nursery.

In working out a plan to bring about callus formation quickly and uniformly for both root and cutting grafts, we have drawn freely on the experiences of French viticulturists and nurserymen. But even their methods have been modified considerably to fit local conditions, such as varied temperatures and rainfall. The use of American scion varieties also entails a changed technic.

For several years past we have placed the grafted cuttings and roots in wood packing cases directly after the operation was done. These boxes are approximately 30 inches long, 14 inches wide, and 17 inches high. The most necessary measurement is the height. A box of such dimensions will hold approximately 600 grafted cuttings, and of course a lesser number of roots. The grafts are placed upright in the box after a layer of 2 inches of sawdust saturated with water has been spread in the bottom. The saturated sawdust is placed between the ends and the grafts, and a layer of like thickness is put between the sides and the grafts. After the box is filled with the grafted cuttings or roots the saturated sawdust is spread to a depth of 2 or 3 inches over the tops of the grafts. Thus, the grafts are entirely surrounded by a layer of saturated sawdust. This material holds heat, allows the entrance of sufficient air, and at the same time provides a humid chamber, all of which are requisite for callus formation. It may be necessary to supply more water once or twice during the time that callusing is taking place. This can best be done thru placing the box in a pan of water that is of the same tem-

perature as the callusing room, allowing the sawdust to take in enough water thru capillary action to bring it to its former condition of saturation.

HEAT AND CALLUS FORMATION

For the past three seasons we have conducted carefully controlled experiments having to do with a study of the amount of heat necessary to callus cutting and root grafts properly. It is suggested from these studies that there is considerable variation among the different varieties in this respect. Vinifera sorts and some American varieties derived from species that are indigenous to the warmer parts of the United States require greater heat to bring about the formation of good callus pads. It is also evident that the quantity of heat required in one season may not be sufficient another year. In short, the growing season which produced the root or the cutting, may have been such that a good reserve of plant food was stored, or the fruit crop may have been so large that all the vine's energies were exhausted in the maturing of the fruit. We have noted that the length of the resting period greatly influences the length of time and the quantity of heat necessary to start grape tissues into activity. Cuttings taken shortly after leaf fall require much greater heat to start them than others taken from the same vines and of the same weight after a portion of the resting period has been passed. These studies suggest that grape cuttings which are to be used either for stocks or scions should not be taken from the parent vines until some time after mid-winter. The lower illustration in Plate IV shows cutting grafts which have been subjected to heat and humidity in the callusing boxes 21 days.

In 1922, Iona, Campbell, Delaware, Worden, and Concord grafted on the cuttings of different stocks were found to be well callused after 27 days in the boxes at a mean interior box temperature of 76°F. These temperatures were recorded on self-registering maximum and minimum thermometers so placed that the lower ends were on a level with the graft union. In order that this mean temperature may be reached on the inside of the box, the mean temperature of the room must be several degrees higher.

In 1923, excellent callusing resulted after 21 days at a mean inside temperature of the boxes of 70°F. To hold this temperature, it was

necessary to maintain a mean room temperature of 78.2°F. It is possible that by using a heated room designed for the purpose and provided with a more uniform heat supply, the length of the callusing period could be materially shortened. While the interior temperatures of the boxes did not fluctuate so widely as the room readings, yet the depression of the room temperature resulted in a considerable lowering of the box temperatures. The irregular heat supply, especially during cold spells, no doubt retarded the progressive formation of cicatricial tissue.

In 1924, a mean interior box temperature of 74.6°F., over a period of 22 days, was required to heal well Concord grafted on one-year Riparia Gloire roots. Concord on Gloire cuttings were well callused two days earlier under practically the same mean temperature. Campbell on Gloire cuttings were well callused with a daily mean temperature of 73.8°F. for the 22 days. Niagara and Worden required 22 days with a daily mean of 74.6°F. The mean room temperature for the period was 81.4°F.

From our studies during the past several seasons of the effective temperatures required to bring grape cuttings of many varieties into growth, it has been noted that with fairly constant greenhouse heat the period from dormancy to the beginning of foliation is much less than 21 days, the minimum period that was required in the tests for complete callus formation.

The use of higher and more uniform heat is desirable in graft callusing, since the scion buds are less likely to put out to such an extent as they do over a more prolonged period. Holding in the callusing boxes is fatal to the expanding buds, especially if the layer of sawdust in contact with them is too wet. In the later days of box callusing it is better to allow this layer to become a trifle dry. Frequent examination after two weeks have elapsed will tell one on which side he is erring.

PLANTING IN THE NURSERY

The grafts should be planted in the nursery row as ordinary grape cuttings, with few exceptions. Greater care must be taken that the grafts do not dry out excessively thru exposure to sunlight or to warm, dry winds. It is a good plan to keep them covered with moistened burlap bagging, if they are taken from the callusing boxes

faster than they are planted and covered. They should be so placed in the trench or furrow that the place of union will stand but an inch or two below the surface of the soil when the trench is filled. A slight ridge should then be thrown up so that the bud on the scion is just exposed. Later in the season this ridge of soil is taken down. The soil should be thoroly compacted as the trench is filled. Two or more times during the growing season it is necessary to remove the soil down to the depth at which the union stands and cut away cleanly and completely all roots that may have started from the scion. If this is not done, insufficient plant food reaches the roots of the stock and, consequently, they do not function normally. It then follows that the stock dies and the scion grows from its own roots, thus thwarting the purpose of grafting. Plate V, left, pictures hand-grafted cuttings with scion roots and a shoot arising on one stock, at the right in Plate V is shown a one-year grafted cutting dug from the nursery.

The French report that from 80 to 90 per cent of their grafted roots and cuttings grow and make desirable plants. Our work thus far has not shown this percentage of successes. A fair average, year in and year out, approximates 50 per cent. In some seasons it has been much higher, while in 1923 the successes were much lower. The grape nurseryman figures on 40 per cent of his Concord cuttings striking root. The increased costs in making grafts and growing them offsets many times the greater percentage of salable grafted plants.

CONCLUSIONS

The conclusions to be drawn from the practices and tests that have been discussed in this bulletin would clearly indicate that the failures from cleft-grafting in the vineyard are due in part to attempts to graft varieties that lack affinity, to grafting at unfavorable periods, to the exclusion of air thru the use of wax or other materials, and to the presence of excessive moisture—a drowning out—that excludes good air circulation. A satisfactory percentage of successes may be assured if the grafting is done before vigorous sap flow begins in the spring or after this flow is past. The cambium layer of both stock and scion must be brought in contact at least at one point. Only one or two turns of a strong string are needed to hold the stock and scion

together firmly, and no grafting wax should be used. That the joined parts do not dry out, a mound of soil should be heaped around the stub and scion to the upper bud of the scion. If the season is wet, the mound should be removed occasionally in order that the soil in contact with the union may dry thoroly. The mound is then put up again. All suckers must be kept off the stock and all scion roots should be cut away from time to time. This can usually be done best when the mound has been leveled for aeration.

It is believed that bench-grafting of grapes can be more successfully done if cuttings from one-year canes are used as stocks. The stocks, if cuttings, are cleanly dis-budded before the scions are fitted. It is emphasized that whether cuttings or one-year roots are used as stocks, they must be of the same diameter as the scion. The length of the stock is somewhat dependent on the depth of the nursery soil in which the grafts are grown, and also on the nature of the soil of the vineyard that is to support them in the future. The deeper the soil, the longer the stock that may be used. As a rule, the stock should be from 8 to 9 inches in length. A one-bud scion is probably preferable to a two-bud scion.

The English whip-and-tongue method has been found very satisfactory for bench-grafting the grape. The joined parts may be held firmly in contact with a minimum of waxed string. Of equal importance to exact matching of stock and scion is the treatment of the grafts from the time of making to the graft planting. Our tests indicate that a very satisfactory plan for the promotion of healing tissue is the storage of the grafts in an upright position in wooden boxes that are lined on all sides, bottom, and top with water-saturated sawdust. This handling provided a humid chamber, while at the same time the heat was more evenly maintained in the interior than was possible otherwise. The temperatures necessary to induce a good growth of callus probably vary with the species and varieties concerned as well as with the previous season in relation to its influence on stored plant food in the stock and scion and the maturity that has been reached by each.

Our tests over a three-year period show that Iona, Campbell, Delaware, Worden, and Concord as scions were well callused after 27 days in the boxes at a daily mean interior temperature of 76°F. in 1922; after 21 days with a daily mean interior temperature of 70°F.,

in 1923; while, in 1924, Concord on Gloire roots had formed a goodly amount of callus after 22 days at a daily mean of 74.6°F.

The grafted cuttings and roots are planted in the nursery row as ordinary grape cuttings, but care must be taken that the grafts are not exposed to sunlight or dry winds for any length of time. They should be so planted that when the trench or furrow is filled the joined parts will stand an inch or two below the soil level. From time to time it is necessary to break out any suckers that may arise from the stock, and it is also imperative that all scion roots be kept cut away.

It is believed that 50 per cent of well-made and callused cutting grafts of Concord, Catawba, etc., may be reasonably expected to grow and become satisfactory plants for vineyard planting. Under better controlled conditions for callusing and with more knowledge of the necessary nursery practices, it is probable that a higher percentage will be possible.